REMARKS

This paper is being provided in response to the Office Action mailed April 23, 2004, for the above-referenced application. In this response, Applicants have amended claims 1, 7, 8, 10, 17, 18 and 21 to clarify that which Applicants consider to be the invention. Applicants respectfully submit that the amendments to the claims are fully supported by the originally-filed specification.

Applicants thank the Examiner for the indication of allowable subject matter in claims 18-20. Applicants have rewritten claim 18 into independent form to incorporate the features of the base claim and any intervening claims. Claims 19 and 20 depend therefrom. Accordingly, Applicants respectfully submit that these claims are in condition for allowance.

The rejection of claims 1-8, 10, 15-17 and 21 under 35 U.S.C. 103(a) as being unpatentable over U.S. Patent No. 4,928,028 to Leibovich (hereinafter "Leibovich") in view of U.S. Patent No. 4,041,336 to Sudler et al. (hereinafter "Sudler") and the separate rejection of claim 9 under 35 U.S.C. 103(a) as being unpatentable over Leibovich in view of Sudler are hereby traversed and reconsideration is respectfully requested in view of the amendments to the claims contained herein.

Independent claim 1, as amended herein, recites an electromagnetic actuator. The actuator includes a stationary assembly includes a hollow stator yoke composed of a soft magnetic material and two coils disposed coaxially and separately in a traveling direction of the actuator inside the hollow stator yoke. A movable assembly is disposed in a hollow space of the

two coils to oppose thereto with a very small clearance. The movable assembly includes a movable magnetic unit and a movable yoke unit, both units mounted on a single supporting shaft adjacently to each other in an axial direction of the supporting shaft. The movable assembly travels in the axial direction by the interaction between a magnetic field generated by the movable magnetic unit and current flowing in the coils. The moveable magnet unit is disposed on said single support shaft so as to oppose said coils radially. Claims 2-6 and 15-16 depend directly or indirectly on independent claim 1.

Independent claim 7, as amended herein, recites an electromagnetic actuator. A stationary assembly includes two coils disposed coaxially with each other inside a hollow stator yoke composed of a soft magnetic material. A movable assembly includes a movable magnet unit and a movable yoke unit both disposed inside the coils with a very small clearance therefrom and both attached to a single supporting shaft such that the movable assembly is movable in the axial direction of the supporting shaft. The movable assembly travels in the axial direction by the interaction between a magnetic field generated by the movable magnet unit and a current passing through the coils, and wherein the movable magnet unit is disposed on the single supporting shaft so as to opposed the coils radially. The two coils are wound on respective separate bobbins made of a synthetic resin and having a substantially identical shape with each other and are disposed axially inside the stator yoke with a predetermined distance provided therebetween. The stator yoke of the stationary assembly is a hollow cylinder and the two coils are ring-shaped and wound on the respective cylindrical bobbins. The movable assembly has a supporting shaft at the center thereof and the movable yoke unit is located such that the movable yoke unit and the two coils effect electromagnetic action on each other. A pair

of flanges are provided at both axial end surfaces of the stator yoke, each flange having a bearing mechanism, and the supporting shaft is retained by the bearing mechanisms so as to be movable in the axial direction. The movable magnet unit of the movable assembly is formed of at least one columnar of hollow magnet axially magnetized with two opposite polarities. The movable yoke unit is constituted by a pair of soft magnetic members that have a substantially identical configuration with each other and are disposed to sandwich the movable magnet unit and to abut against a north-pole end surface and a south-pole end surface thereof. The outer diameter of the movable magnet unit of the movable assembly is set to be smaller than the outer diameter of the movable yoke unit.

Independent claim 8, as amended herein, recites features similar to that of independent claim 7 except that the pair of magnets are magnetized so that the inward portion and the outward portion of one magnet are polarized oppositely from each other and the outward portion of one magnet is polarized oppositely from the outward portion of the magnet. Claim 9 depends from independent claim 8.

Independent claim 10, as amended herein, recites an electromagnetic actuator. The actuator includes a stationary assembly that includes a hollow stator yoke composed of a soft magnetic material and a plurality of paired coils each of which is composed of two coils disposed separately in a traveling direction of the actuator inside the hollow stator yoke. A movable assembly includes the same number of pairs of a movable magnet unit and a movable yoke unit as the number of the paired coils and is disposed in a hollow space of the paired coils to oppose thereto with a very small distance. The movable assembly is mounted on a single supporting

shaft such that the movable assembly is movable in the axial direction of the supporting shaft. The movable assembly travels in the axial direction by the interaction between a magnetic field generated by the movable magnet unit and a current flowing in the paired coils. The moveable magnet unit is disposed on said single support shaft so as to oppose said coils radially.

Independent claim 17, as amended herein, recites an electromagnetic actuator. A stationary assembly includes two coils disposed coaxially with each other inside a hollow stator yoke composed of a soft magnetic material. A movable assembly includes a movable magnet unit and a movable yoke unit both disposed inside the coils with a very small clearance therefrom and both attached to a single supporting shaft such that the movable assembly is movable in the axial direction of the supporting shaft. The movable assembly travels in the axial direction by the interaction between a magnetic field generated by the movable magnet unit and a current passing through the coils. The movable magnet unit is disposed on the single supporting shaft so as to opposed the coils radially.

Independent claim 21, as amended herein, recites an electromagnetic actuator. A stationary assembly includes a hollow stator yoke composed of a soft magnetic material and two coils disposed coaxially and separately in a traveling direction of the actuator inside the stator yoke. A movable assembly is disposed in a hollow space of the two coils to oppose thereto with a very small clearance. The movable assembly includes a movable magnet unit and a movable yoke unit, both units mounted on a single supporting shaft adjacently to each other in an axial direction of the supporting shaft. The movable assembly travels in the axial direction by the interaction between a magnetic field generated by the movable magnet unit and a current flowing

in the coils, and wherein the movable magnet unit is disposed on the single supporting shaft so as to oppose the coils radially. The outer diameter of the movable magnet unit of the movable assembly is set to be smaller than the outer diameter of the movable yoke unit.

The Leibovich reference discloses a proportional permanent magnet force actuator. The actuator includes first and second electromagnets, each having a cup-shaped ferromagnetic stator core with an axially extending concentric annular main pole member on the centerline thereof. An armature in the actuator is spring-biased to a neutral position and includes a disc-shaped permanent magnet configured for being received within the inner opening of the common pole and is sandwiched between first and second disc-shaped pole members. Energization of the coils simultaneously provides a first attractive force between a first armature pole and a common pole, a repulsive force between the first armature pole and a first main electromagnet pole, a second attractive force between the second armature pole and the second main electromagnet pole and a second repulsive force between the second armature pole and the common pole. (See Abstract, col. 3, lines 15 – 30 and Fig. 3 of Leibovich).

The Sudler reference discloses a single phase stepper motor. The Office Action cites Sudler as disclosing the use of a soft magnetic material in the stator core.

Applicants' independent claims, as amended herein, recite at least the features of an electromagnetic actuator having a movable assembly disposed in a hollow space of two coils to oppose thereto with a very small clearance that includes a movable magnet unit and a movable yoke unit, both units mounted on a single supporting shaft adjacently to each other in an axial

direction of the supporting shaft, wherein the movable assembly travels in the axial direction by the interaction between a magnetic field generated by the movable magnet unit and a current flowing in the coils, and wherein the movable magnet unit is disposed on the single supporting shaft so as to oppose said coils radially. The actuator of the present claimed invention operates according to Fleming's left hand rule applied to the mutual action between the magnetic field produced by the movable magnet unit and the current flowing in the coils. (See, for example, page 13, line 6 to page 15, line 4). In this way, the movable assembly can be brought to its target position by monitoring the current position of the movable assembly relative to the target position and continuously changing the direction and value of current according to the monitoring. In contrast, the actuator of Leibovich operates by the action of magnetic attraction and repulsion between pole members (58, 59) and the magnetic disc members (73, 74). (See, for example, Fig. 3 of Leibovich.)

In the present invention, the movable yoke unit and the movable magnet unit are mounted on the supporting shaft in a configuration that opposes the coil assemblies radially. On the other hand, in the actuator of Leibovich, the sandwiched structure of the magnetic disc members (armature poles) 73, 74 and the permanent magnet 72 attached to the shafts 75 and 76 does not oppose to the coils 60 and 61 radially, but rather opposes them in the axial direction.

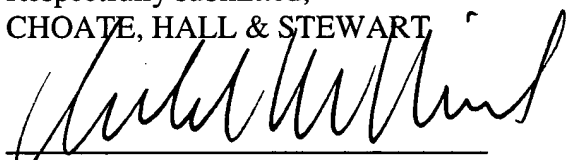
Further, the actuator of Leibovich does not have a single shaft, but rather has two separate shafts 75 and 76. (See, for example, Fig. 4 of Leibovich.) In contrast, the actuator of the present claimed invention has a single supporting shaft extending in the stator yoke in its axial direction. Additionally, Leibovich's device includes spring members 64, 65 to bias the

armature in a neutral position; however, such spring members are not necessary in the configuration of Applicants' claimed invention.

Applicants' respectfully submit that the Sudler reference does not overcome the above noted deficiencies of the Leibovich reference with respect to Applicants' claims. Specifically, Applicants respectfully submit that neither Sudler nor Leibovich, taken alone or in combination, teach or fairly suggest at least the features of an electromagnetic actuator having a movable assembly disposed in a hollow space of two coils to oppose thereto with a very small clearance that includes a movable magnet unit and a movable yoke unit, both units mounted on a single supporting shaft adjacently to each other in an axial direction of the supporting shaft, wherein the movable assembly travels in the axial direction by the interaction between a magnetic field generated by the movable magnet unit and a current flowing in the coils, and wherein the movable magnet unit is disposed on the single supporting shaft so as to oppose said coils radially. Accordingly, Applicants respectfully request that the rejection of Applicants' claims be reconsidered and withdrawn.

Based on the above, Applicant respectfully requests that the Examiner reconsider and withdraw all outstanding rejections and objections. Favorable consideration and allowance are earnestly solicited. Should there be any questions after reviewing this paper, the Examiner is invited to contact the undersigned at 617-248-4038.

Respectfully submitted,
CHOATE, HALL & STEWART



Date: July 13, 2004

Donald W. Muirhead
Registration No. 33,978

Choate, Hall & Stewart
Exchange Place
53 State Street
Boston, MA 02109
Phone: (617) 248-5000
Fax: (617) 248-4000